NL000452
US

jc997 U.S. PTO
09/923611
08/07/01

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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

00202818.1

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.: 00202818.1
Demande n°:

Anmeldetag:
Date of filing: 09/08/00
Date de dépôt:

Anmelder:
Applicant(s):
Demandeur(s):
Koninklijke Philips Electronics N.V.
5621 BA Eindhoven
NETHERLANDS

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Method of manufacturing a magnetic head having a planar coil

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat: State: Pays:	Tag: Date: Date:	Aktenzeichen: File no. Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:
/

Am Anmeldetag benannte Vertragstaaten:
Contracting states designated at date of filing: AT/BE/CH/CY/DE/DK/ES/FI/FR/GB/GR/IE/IT/LI/LU/MC/NL/PT/SE/TR
Etats contractants désignés lors du depôt:

Bemerkungen:
Remarks:
Remarques:

Method of manufacturing a magnetic head having a planar coil

The invention relates to a method of manufacturing a magnetic head provided with a head face and including a magnetic coil extending parallel to the head face.

Such a method is known from the paper IEEE Transactions on Magnetics, Vol. 25, No. 5, September 1989, pages 3190-3193. This paper describes a fabrication process for realizing thin film heads on silicon, called IC heads, for high-density magnetic recording. The fabrication process starts from a silicon wafer in which grooves are etched. In these grooves magnetic heads including conductor spirals are formed. At the end of the process air bearing surfaces are formed and sliders are defined by etching before dicing the wafer into separate components.

One way to realize high-density recording is to apply magneto-optical (MO) recording. In such a recording process data are written in a magnetic recording layer of a magnetic medium, e.g. a disk, by using a magnetic field for polarizing magnetic particles in the recording layer. Information can be read out from such a layer by optically detecting the Kerr rotation of polarized light, which is reflected from the relevant layer. For most magnetic media a relatively high magnetic field is required to achieve a complete polarization of the magnetic material due to the high coactive of the medium. Heating up a magnetic medium reduces drastically the threshold value of the magnetic field intensity that is necessary for a complete polarization. Thermally assisted magnetic recording makes use of this phenomenon. In e.g. MO writing strategies with Laser Pulsed Magnetic Field Modulation (LP-MFM) a laser pulse is used to locally heat a magnetic medium while a magnetic field, which is synchronized with the timing of the laser pulse, polarizes the heated area. A magnetic head suitable for LP-MFM magneto-optical recording should have a magnetic-field-modulation ~~(MFM) coil~~ and usually has a transparent guide for ~~guiding a laser~~ beam. The laser beam can be used for both heating of a magnetic medium and reading of data from the magnetic medium via the detection of the Kerr effect. Usually, the transparent guide is co-axially arranged with the coil. In order to achieve sufficient high magnetic field intensities with limited power consumption the inner radius of the coil is as small as possible.

The size of the data bits which can be written by thermally assisted magnetic recording on a MO medium is limited by the size of the spot of the focussed laser beam and the thermal profile of the spot, and the thermal properties of the medium itself. The optical size of the spot depends on the wavelength (λ) of the laser light used and the numerical aperture (NA) of the optical path yielding a diffraction limited spot with a radius (r) of the order of 0.61 λ/NA. In near field recording a NA in excess of 1 is possible by using the evanescent waves, which occur at a surface of total internal reflection of a refractive optical component. A requirement is that the magnetic head, particularly the optical component thereof, is positioned with regard to the recording medium at a distance which is only a fraction of the wavelength of the laser light used. It is expected that the head to medium distance decreases towards the submicron range in order to realize higher recording densities in MO recording, such as near field recording.

In a system for magnetic recording into a storage medium optical components are combined with a slider, the slider being carried by a suspension and positioned below an objective lens of an actuator, a MFM coil being integrated in the slider. The slider is provided with an Air Bearing Surface (ABS) for flying during use on an air bearing at a surface of the storage medium.

It is essential for such a slider that the coil of the magnetic head is a planar coil near to the plane of the ABS. In the method described in the previously mentioned IEEE paper this is realized by forming a ditch in a silicon wafer, whereafter a coil is buried in the ditch. A disadvantage of this known method is that making a ditch is laborious. Moreover, such a ditch is difficult to realize in most optical materials, such as multicomponent glasses, because these materials are in general difficult to etch. As the coil structures are defined using photo lithographic techniques, making a coil in a recess is a critical process because of the topography involved. In addition to this, an intermediate planarization between subsequent coil-layers is mechanically impossible.

It is an object of the invention to provide a simple method of manufacturing a magnetic head in which a planar coil is situated near to the head face.

This object is achieved by the method of manufacturing a magnetic head provided with a head face and including a magnetic coil extending parallel to the head face, in which method the magnetic coil is formed at a first side of a first substrate, whereafter the first substrate provided with the magnetic coil is adhered, particularly glued, with the first side to a side of a second substrate, whereafter material of the first substrate is removed from

a second side of the first substrate, which second side is turned away from the first side, for forming the head face .

The method according to the invention implies only a few mask steps needed for realizing a planar magnetic coil close to the head face. In case of a magnetic head, which is intended for use in a slider the magnetic head may be integrated in the slider, the head face forming at least a part of an air bearing surface.

In an embodiment of the method according to the invention the first substrate may be a substrate of silicium provided with a top layer, e.g. an oxide, such as SiO_2 or ZrO_4 or a hard material, such as diamond, this top layer being adjacent to the first side of the first substrate. In general the top layer forms the first side of the first substrate. The substrate of silicium may be a Si wafer. After adhering the first substrate to the second substrate at least a part of the substrate of silicium is removed for forming the head face. This can take place by etching; preferably by means of a selective etching process which stops at the top layer, like e.g. hot KOH etchant which is a selective etchant for Si and SiO_2.

In an embodiment of the method according to the invention after a step involving forming a layer of a metal on the first substrate at least one further step involving forming a layer of a non-conducting material and forming a further layer of a metal and forming interconnections between two neighboring layers of metal is performed to create the magnetic coil. The layers of metal can be formed by deposition, e.g. by means of a galvanical growth, of a suitable metal, such as Cu. The layer of a non-conducting material can be formed by depositing e.g. an oxide, such as Al_2O_3, or by spin coating of a polymer or in every other suitable way, such as spin-on-glass. The interconnection can be formed after forming holes in the layer of non-conducting material, e.g. by etching. The interconnection may also be formed by means of a lithographic process.

The non-conducting layer can be planarized by means of e.g. a polishing procedure, such as chemical-mechanical polishing thus improving the quality of the coil.

In an embodiment of the method according to the invention a substrate of a glass material is applied as the second substrate. This method results in a magnetic head having transparent portions. Such a head may be used as MO-head and can have a light guide.

In an additional step the transparent guide can be made out of refractive indexed matched material with the glass substrate in order to avoid optical problems like unwanted reflections on interfaces.

A further object of the invention is to provide a method of manufacturing a slider, in particular a slider applicable into a system for magneto-optical recording, by means of which method it is possible to realize a magnetic coil, a defined air bearing surface and a defined location of the magnetic coil with regard to the air bearing surface in a limited number of method steps.

This further object is achieved by the method of manufacturing a slider provided with an air bearing surface and including a planar magnetic coil extending parallel to the air bearing surface, in which method the magnetic coil is formed at a first side of a first substrate, whereafter the first substrate is adhered with the first side to a side of a second substrate, whereafter material of the first substrate is removed from a second side of the first substrate, which second side is turned away from the first side, for forming a face, whereafter the face is structured for forming the air bearing surface. Standard technology can be used to carry out the few steps of the method according to the invention. Removal of material of the first substrate and structuring of the said face may take place preferably by etching. Virtually, the formed magnetic coil is part of a magnetic head integrated in the obtained slider. Obviously, the magnetic coil has leads for electrical connections.

In an embodiment of the method of manufacturing a slider according to the invention on a substrate of silicium a top layer of an insulating material is provided for forming the first substrate, the top layer being adjacent to the first side, wherein a substrate of glass is applied as the second substrate, and wherein after adhering the first substrate to the second substrate the substrate of silicium is removed. In general the top layer forms the first side. The substrate of silicium can be a wafer of silicium. The top layer can be an oxide, such as SiO_2.

Because the top layer functions as a protection layer for the obtained slider to avoid damages of the slider during use, e.g. owing to a crash with the surface of a recording medium or a bump into dust particles, a top layer of a hard material, such as a diamond like coating or a layer or ZrO_2, is preferred. It is advantageous that the protection layer does not require any additional step, but is simply formed by the top layer of the first substrate.

An embodiment of the method of manufacturing a slider is characterized in that during forming of the magnetic coil a metallic layer is formed beside the magnetic coil, which metallic layer is at least partly removed for forming a recess during structuring of the face for forming the air bearing surface. The metallic layer is preferably formed by deposition of the same metallic material as used for forming the magnetic coil, e.g. Cu.

Removal of metallic material can simply occur by etching, e.g. by using a standard Cu etchant. The depth of the desired recess can be tuned by the thickness of the metallic layer.

An embodiment of the method is characterized in that during forming of the magnetic coil a heat sink layer is formed beside the magnetic coil in the making. A suitable material for the heat sink layer is Cu, which can also be used as material for the magnetic coil. The heat sink layer is preferably positioned around or partly around the magnetic coil. The heat sink layer in the resulted slider serves to transport heat from the magnetic coil to one or more edges of the slider where air cooling and radiation can be very effective in order to cool the slider. If desired a real thermal connection between the heat sink and a cooling body with an enlarged area or active coolant, like a Peltier element, can be realized.

In another embodiment a stack of interconnected coil layers is formed for creating the magnetic coil.

It should be noticed that the claimed method of manufacturing a slider implies related advantages and effects as obtained by the claimed method of manufacturing a magnetic head.

The invention further relates to a slider manufactured by means of the method according to the invention. The slider according to the invention has a planar magnetic coil adjacent to an air bearing surface and is preferably locally transparent, such that a light beam can axially pass a central area of the coil. The slider has preferably the feature as defined in Claim 11.

Furthermore, the invention relates to a system for magnetically or magneto-optically recording information into a storage medium, the system including the slider according to the invention.

With reference to the Claims, it is noted that various characteristic features as defined in the set of Claims may occur in combination.

The above-mentioned and other aspect of the invention are apparent from and will be elucidated, by way of non-limitative example, with reference to the embodiments described hereinafter.

In the drawing:

Figures 1 to 8 represent diagrammatically various steps of an embodiment of a method according to the invention, in which

Figure 8 also shows a first embodiment of the slider according to the invention,

Figure 9A shows diagrammatically in a cross section a second embodiment of the slider according to an invention,

Figure 9B shows in a section IXB-IXB through Figure 9A the second embodiment and

Figure 10 shows diagrammatically in a perspective view an embodiment of a system according to the invention.

An embodiment of the method according to the invention of manufacturing a slider <u>10</u> will now be described with reference to Figures 1 to 8. This embodiment starts from a substrate 1 of silicium which substrate 1 may form part of a Si-wafer. An insulation material, particularly an oxide such as SiO_2 or Al_2O_3 is deposited on a main face of the substrate 1, for example, thermal oxidation, by means of sputtering or vapor deposition, for forming a thin top layer 3 having a thickness of e.g. 0.5 um. The substrate 1 and the top layer 3 together form a first substrate having a first side 5a and a second side 5b being parallel to the first side 5a. A first conductive or metallic layer 7a provided with one or more coil turn sections is formed at the first side 5a of the first substrate, for example, by means of sputter deposition or electro deposition of copper or another suitable electrically conductive material. Then a non-conducting layer 7b is formed on the first conductive layer 7a by e.g. deposition of S_iO_2 or Al_2O_3, or by spincoating of a polymer. Thereafter a second conductive layer 7c is formed on the insulating layer 7b and an interconnection between the first and second conductive layers is made, e.g. by locally etching the non-conducting layer 7b before forming the second conductive layer 7c.

The layers 7a, 7b and 7c together form a planar magnetic coil 7 having a coil axis 7A. It is to be noted that in another embodiment the coil 7 may only have one conductive layer. After forming the coil 7 the first substrate is adhered, particularly glued, with the first side 5a, which side has been shifted in this embodiment owing to technology steps, to a side 9a of a second substrate 9 of e.g. glass. The second substrate 9 may form part of a glass wafer. A suitable glue is e.g. acrylate resin varnish; 1,6-hexanediodiacrylate. In a next step the substrate 1 is removed, particularly etched away in e.g. hot KOH, resulting in a face 13. Subsequently the face 13 is structured by first locally removing the top layer 13, e.g. by locally ~~etching away~~ insulation material, and then locally removing ~~material of~~ one or more laid open portions 7B of the first conductive layer 7a, e.g. by locally etching, in order to create an air bearing surface 15 being the face 13 provided with one or more recessed portions 13a. In case Cu is used as conductive material for the coil 7 a standard Cu etchant

may be used in forming the air bearing surface 15. The depth of the recessed portion or portions 13a can be tuned by using multiple metallic layers.

The air bearing surface 15 of the slider obtained by the above described method serves during use of the slider to control the flow of air produced between a surface of a moving storage medium and the slider <u>10</u> located adjacent said surface, in order to avoid contact of the slider with the storage medium.

It is to be noticed that the above-described method can also be used for manufacturing a magnetic head. In that case the method steps as shown in the Figures 7 and 8 can be omitted. This means that the product shown in Figure 6 may be a magnetic head, the face 13 forming a head face. Both in case of the slider and the magnetic head the top layer may function as a protective layer.

It is further to be noted that the slider as shown in Figure 8 has a transparent coil center 7C and is transparent along the coil axis 7A due to a suitable choice of transparent materials, whereby the slider is transparent for a bundle of light going through said center.

In a variant of the above-described embodiment a heat sink layer is formed during forming the coil 7. In Figures 9A and 9B an embodiment of the slider according to the invention provided with a heat sink 17 is shown. Elements of this variant which correspond to similar elements of the already described embodiment have got the same reference signs. In the relevant variant the heat sink is formed simultaneously with the coil 7 by means of deposition of the same metal as deposited for forming the magnetic coil 7 and its connection faces $7f_1$, and $7f_2$. The heat sink 17 is positioned adjacent to, i.e. at least partly around and/or above or beneath the magnetic coil 7, and has the function to transport heat from the turn or turns of the coil to the borders of the slider where convention and radiation effectively cool the slider during its use. In a special embodiment a thermal connection between the heat sink and a cooling body with an enlarged area or an active coolant like a Peltier element may be realized.

An embodiment of the system according to the invention, shown in Figure 10, is suitable for writing and/or reading a magneto-optical information disk 100. The disk 100 is rotably supported by an electrically drivable spindle mounted in a base. During use the disk 100 is rotated in a rotational direction, indicated by the arrow A. The system is provided with an arm 102 translatably held on the base and provided with a flexure 102a carrying an embodiment of the slider according to the invention, here indicated by the numeral <u>110</u>, having a transparent body indicated by the numeral 104. An electrical drive is provided for translating the arm 102, during translation the slider <u>110</u> being moved in radial directions,

indicated by the arrow B of the disk 100. During writing and/or reading the air-bearing surface of the slider is located opposite to and at a distance from a mainface of the disk 100. The arm 102 carries a lens section 106 having an optical axis 106a going through the transparent center of the magnetic coil of the slider 110. The coil is here indicated by the numeral 107.

The system according to the invention can be a data storage system. Alternatively, the system may be an audio and/or video system. A rotatable arm may be used instead of a translatable arm.

CLAIMS:

09. 08. 2000

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1. A method of manufacturing a magnetic head provided with a head face and including a magnetic coil extending parallel to the head face, in which method the magnetic coil is formed at a first side of a first substrate, whereafter the first substrate provided with the magnetic coil is adhered with the first side to a side of a second substrate, whereafter material of the first substrate is removed from a second side of the first substrate, which second side is turned away from the first side, for forming the head face.

2. A method according to Claim 1, wherein a substrate of silicium provided with a top layer of an insulating material is applied as the first substrate, the top layer being adjacent to the first side.

3. A method according to Claim 2, wherein after a step involving forming a layer of a metal on the first substrate at least one further step involving forming a layer of a non-conducting material and forming a further layer of a metal and forming interconnections between two neighboring layers of metal is performed to create the magnetic coil.

4. A method according to Claim 1, wherein a substrate of a glass material is applied as the second substrate.

5. A method of manufacturing a slider provided with an air bearing surface and including a planar magnetic coil extending parallel to the air bearing surface, in which method the magnetic coil is formed at a first side of a first substrate, whereafter the first substrate is adhered with the first side to a side of a second substrate, whereafter material of the first substrate is removed from a second side of the first substrate, which second side is turned away from the first side, for forming a face whereafter this face is structured for forming the air bearing surface.

6. A method as claimed in Claim 5, wherein on a substrate of silicium a top layer of an insulation material is provided for forming the first substrate, the top layer being

adjacent to the first side, wherein a substrate of glass is applied as the second substrate and wherein after adhering the first substrate to the second substrate the substrate of silicium is removed.

7. A method as claimed in Claim 5, wherein during forming of the magnetic coil a metallic layer is formed beside the magnetic coil, which metallic layer is at least partly removed for forming a recess during structuring of the face for forming the air bearing surface.

8. A method as claimed in Claim 5, wherein during forming of the magnetic coil a heat sink layer is formed beside the magnetic coil in the making.

9. A method as claimed in Claim 5, wherein a stack of interconnected coil layers is formed for creating the magnetic coil.

10. A slider manufactured by the method according to the Claims 5 to 9.

11. A slider as claimed in Claim 10, wherein the top layer forms a protective layer for the slider.

12. A system for magnetically or magneto-optically recording information into a storage medium, the system including the slider according to Claim 10.

ABSTRACT:

A simple method of manufacturing a magnetic head provided with a head face and including a planar magnetic coil (7) extending parallel to the head face. According to the method the magnetic coil is formed at a first side of a first substrate (1). Thereafter the first substrate provided with the magnetic coil is adhered with the first side to a side of a second substrate, whereafter material of the first substrate is removed from a second side of the first substrate (9), the second side being turned away from the first side, for forming the head face, such that the magnetic coil is situated near to the head face.

(Figure 5)

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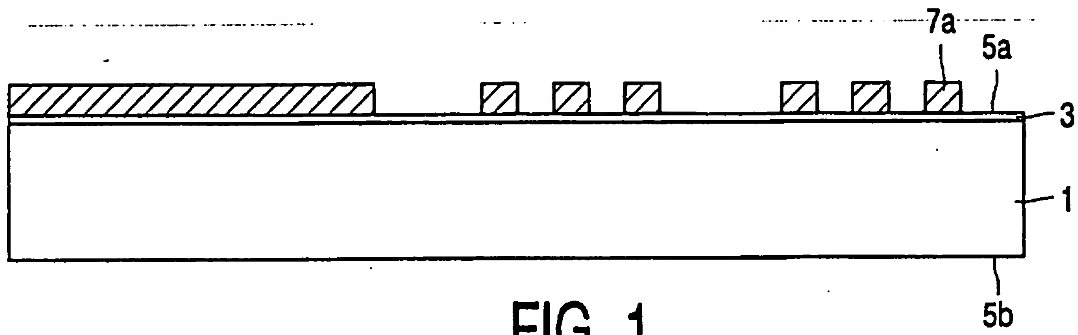

FIG. 1

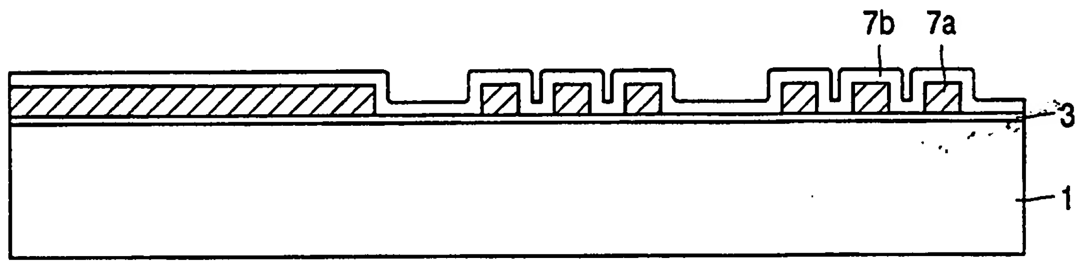

FIG. 2

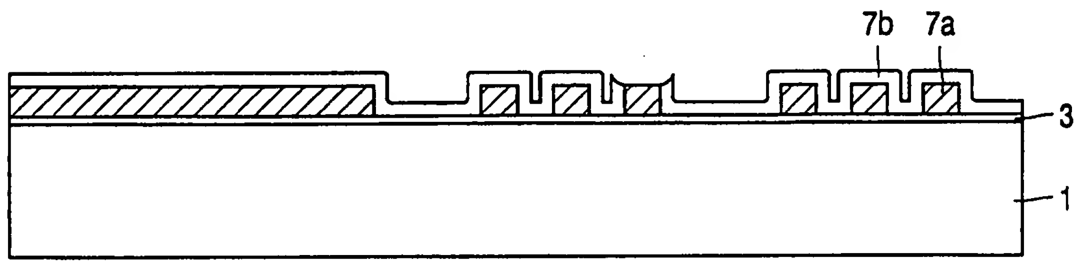

FIG. 3

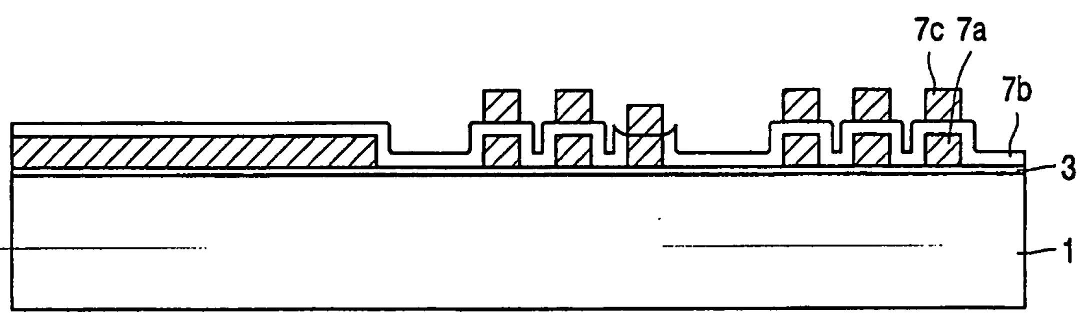

FIG. 4

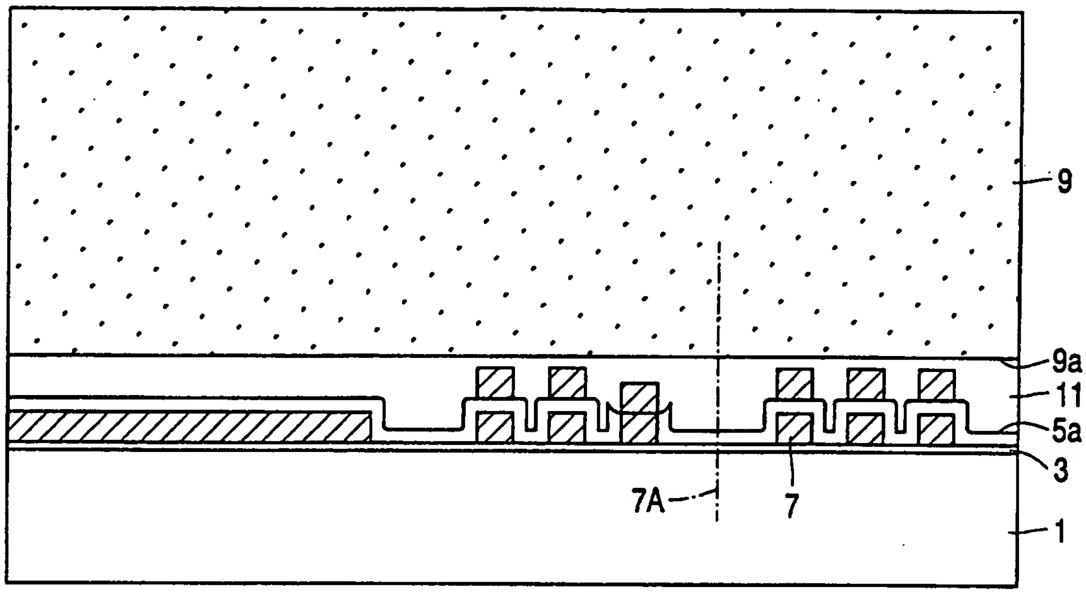

FIG. 5

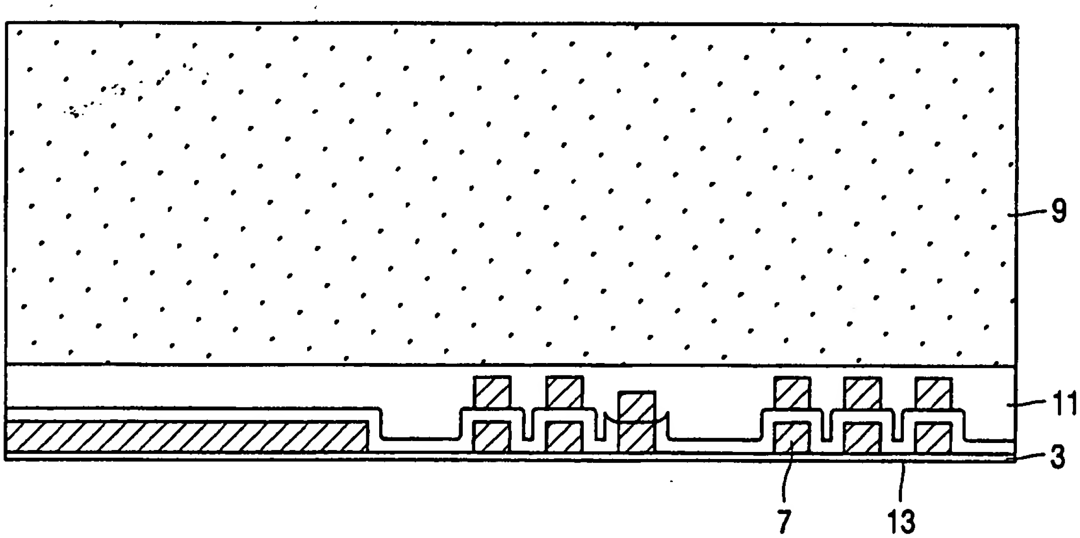

FIG. 6

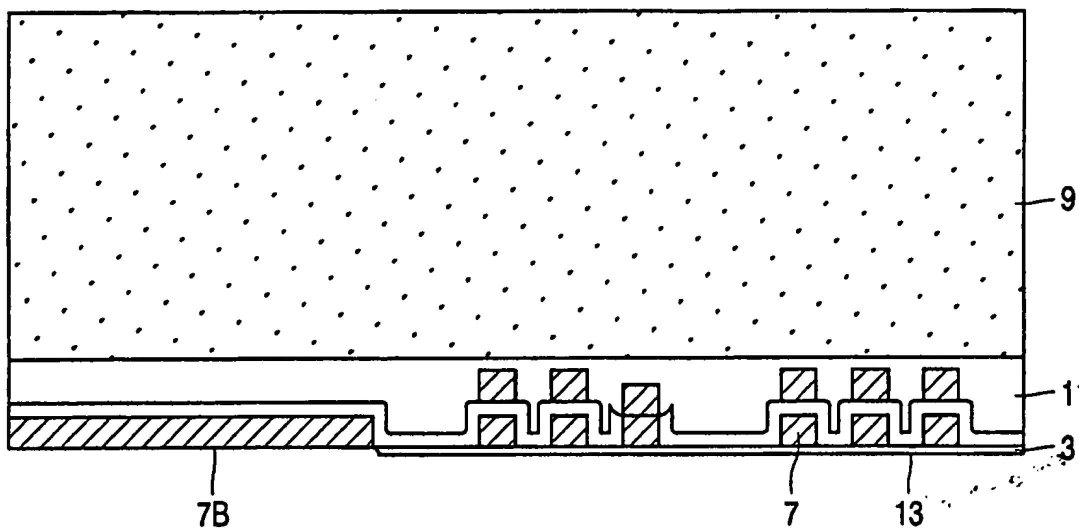

FIG. 7

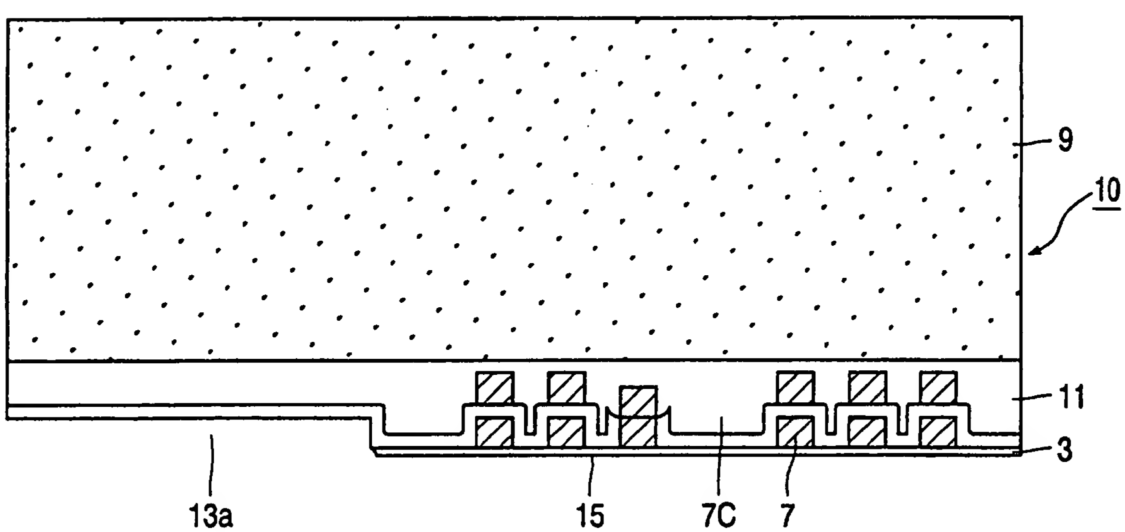

FIG. 8

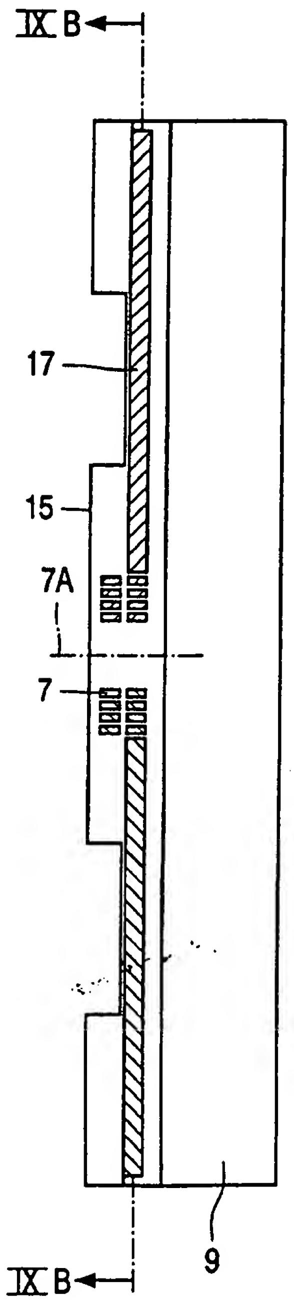

FIG. 9A

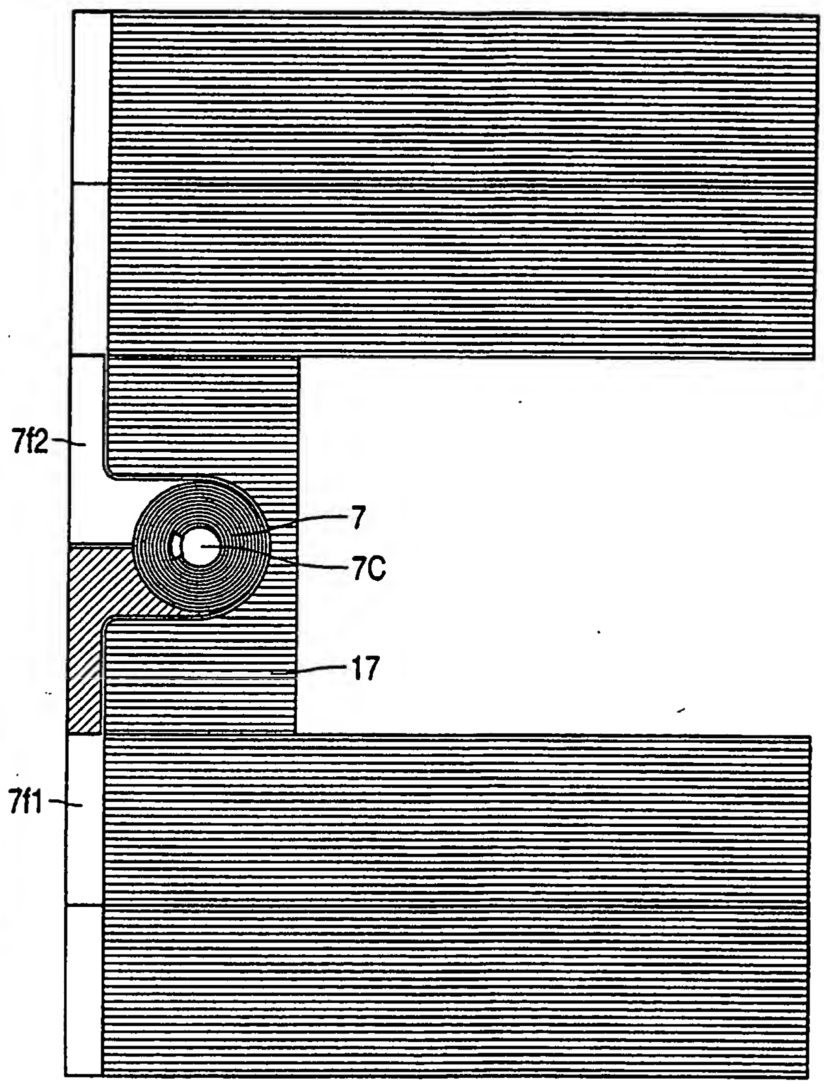

FIG. 9B

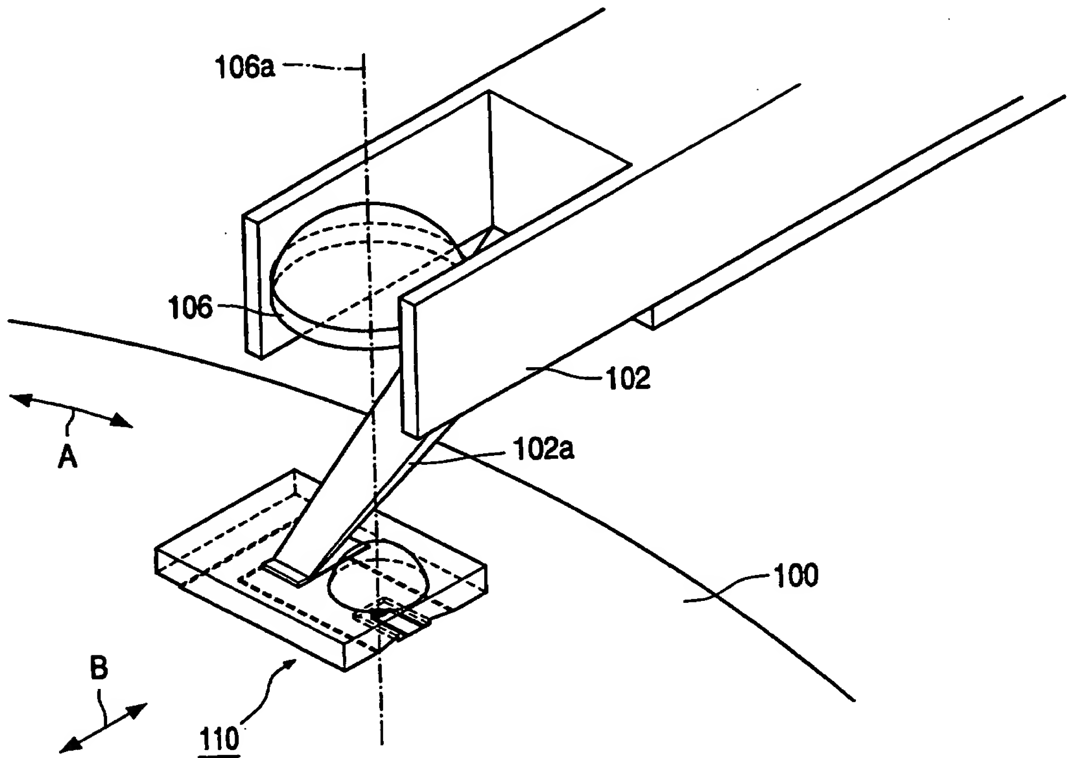

FIG. 10